STREAM-VORTICITY FORMULATION FOR 2-DIMENSIONAL NAVIER-STOKES FLOW USING MESHFREE POINT COLLOCATION METHOD

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We apply the point collocation method based on the fast moving least square reproducing kernel(FMLSRK [1]) approximation to the stream-vorticity formulation for the stationary incompressible Navier-Stokes flow in $\mathbb{R}^2$. Recently, we extended the FMLSRK method to the case of variable dilation parameter which is called the dilation function.[2] Even in that case, we proved the reproducing properties are still satisfied. The extended FMLSRK method enables us to deal with node concentration. In this paper, we use the extended FMLSRK method.
With the stream function, we split the Navier-Stokes equations into coupled second order partial differential equations with Dirichlet boundary conditions. One is induced from the definition of vorticity and another becomes the vorticity transport equation. For the vorticity transport equation with Dirichlet condition, we have to impose the trace of vorticity on the wall boundary associated with the boundary conditions of stream function. Of course, this situation also occurs in the other methods like FDM or FEM. To do this within the scope of our meshfree method, we adapt the approximations derived from the extended FMLSRK method mentioned above in which all of the approximated derivatives of the shape functions can be obtained without additional cost. As numerical experiments, we illustrate the lid-driven cavity flow, the backward facing step flow and the exterior flow passing around a cylinder with the far field velocity uniform. The last example require the node concentration near the cylinder inevitably and thus the dilation function plays an important role in calculating the exterior flow.

References

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[2] Do Wan Kim, Y. Kim, Y. C. Kim, H. S. Kim, S. Ahn, Y. Y. Park and Dae-Wook Kim,"A Miniaturized Electron Beam Column Simulation by the Fast Moving Least Square Reproducing Kernel Point Collocation Method", *Japanese J. Appl. Phys.*, to appear (2003)
[3] D. W. Kim and Y. Kim,"Point Collocation Scheme for the Stationary Incompressible Navier-Stokes Equations by FMLSRK",*preprint*